SOLAR/1051-79/05

Monthly Performance Report

COLORADO SUNWORKS

MAY 1979

U.S. Department of Energy

National Solar Heating and Cooling Demonstration Program

National Solar Data Program

I. SYSTEM DESCRIPTION

The Colorado Sunworks solar energy system is a passive solar energy system used for both space heating and domestic hot water preheating of a single-family dwelling located in Longmont, Colorado. The building is a three bedroom single-story house with approximately 1,800 square feet of living space as illustrated in Figure 1.

The passive space heating system, illustrated schematically in Figure 2, is a combination drum wall and direct gain system. Sunlight enters the double-glazed windows (approximately 300 square feet) on the south side of the building where the majority of the energy is absorbed by the black painted 55-gallon water-filled drums (54 drums total). The remainder of the energy is either absorbed in the 6-inch thick concrete slab floor or used to satisfy the daytime space heating demand. The 8-inch thick exterior insulated reinforced concrete building walls also serve as a secondary solar storage mass.

At night, or during periods of low incident solar energy, heat losses through the glazing are reduced by using movable insulation in the form of a Beadwall.* The Beadwall is constructed using the two panes of glass spaced 5-1/2 inches apart. Beads of white-colored rigid insulation can be blown into the space between the glass or sucked out using electrically driven blowers. When not used for south wall insulation, the beads of insulation are stored in tanks located in the garage. Operation of the Beadwall is automatically controlled based on sensors measuring incident solar energy and inside and outside temperature. This automatic operation may be manually overridden.

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* Beadwall® is a registered trademark of the Zomeworks Corporation, Albuquerque, NM.

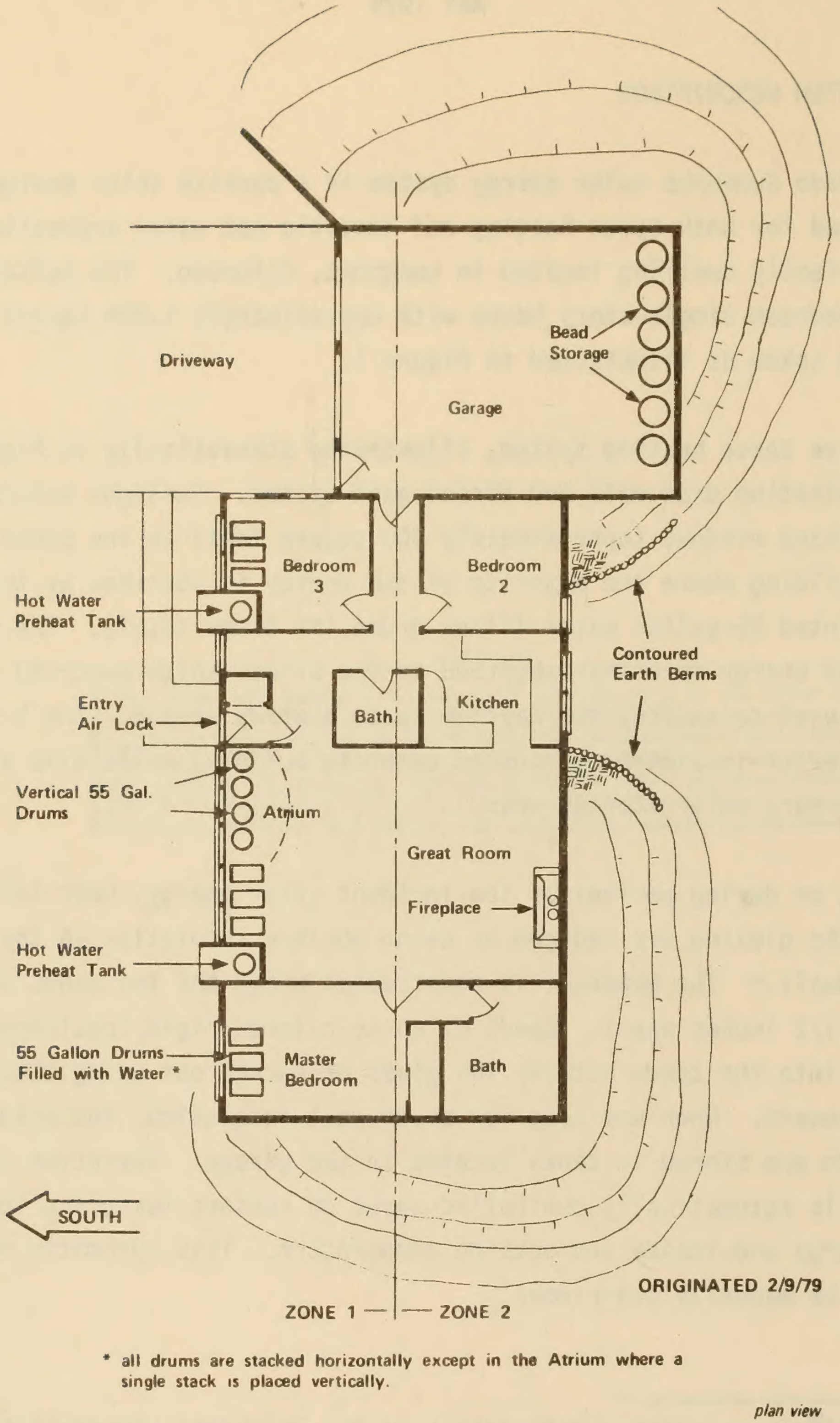

Figure 1. COLORADO SUNWORKS PASSIVE SOLAR SPACE HEATING SYSTEM

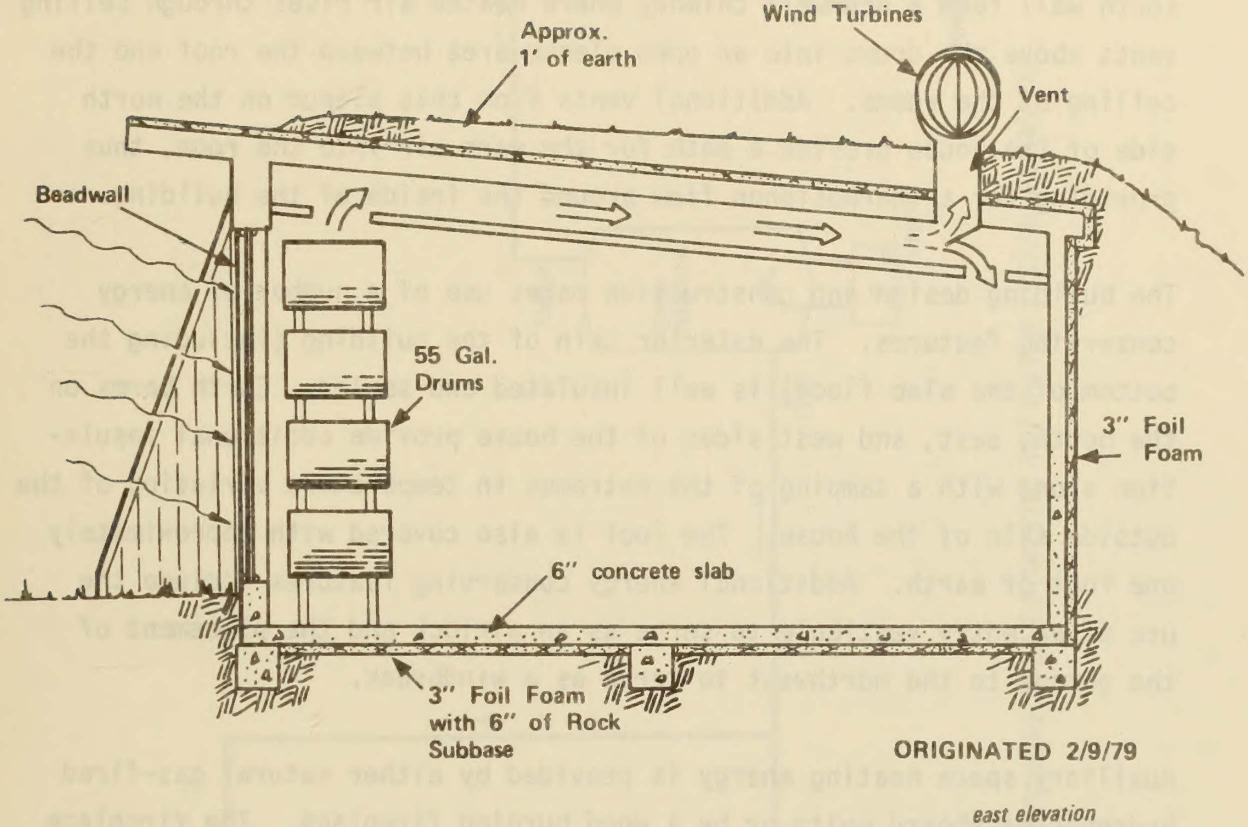

Figure 2. COLORADO SUNWORKS PASSIVE SOLAR SPACE HEATING SYSTEM

Distribution of the collected solar energy to the house is by both convection and radiation. A unique feature of this building is the technique used for distribution of collected solar energy from the drums to the north side of the house. The vertically stacked drums near the south wall form a drumwell chimney where heated air rises through ceiling vents above the drums into an open plenum area between the roof and the ceiling of the rooms. Additional vents from this plenum on the north side of the house provide a path for the warm air into the room, thus providing for a thermosiphon flow around the inside of the building.

The building design and construction makes use of a number of energy conserving features. The exterior skin of the building (including the bottom of the slab floor) is well insulated and sealed. Earth berms on the north, east, and west sides of the house provide additional insulation along with a damping of the extremes in temperature variation of the outside skin of the house. The roof is also covered with approximately one foot of earth. Additional energy conserving features include the use of an entry vestibule to serve as an airlock and the placement of the garage to the northwest to serve as a windbreak.

Auxiliary space heating energy is provided by either natural gas-fired hydronic baseboard units or by a wood burning fireplace. The fireplace has a provision for recirculation of room air while providing outside air for combustion.

The passive solar domestic hot water system (Figure 3) consists of two 30-gallon tanks which have been stripped of their insulation, painted black, and positioned next to the south wall (Figure 1). Domestic hot water is preheated in these tanks before passing on demand to the natural gas-fired domestic hot water tank where it is raised to operating temperature. The preheat tanks are insulated from the living space by interior walls, and are insulated from the outside conditions at night using the Beadwall movable insulation. Reflective surfaces inside the insulated spaces enhance the absorption of incident solar radiation.

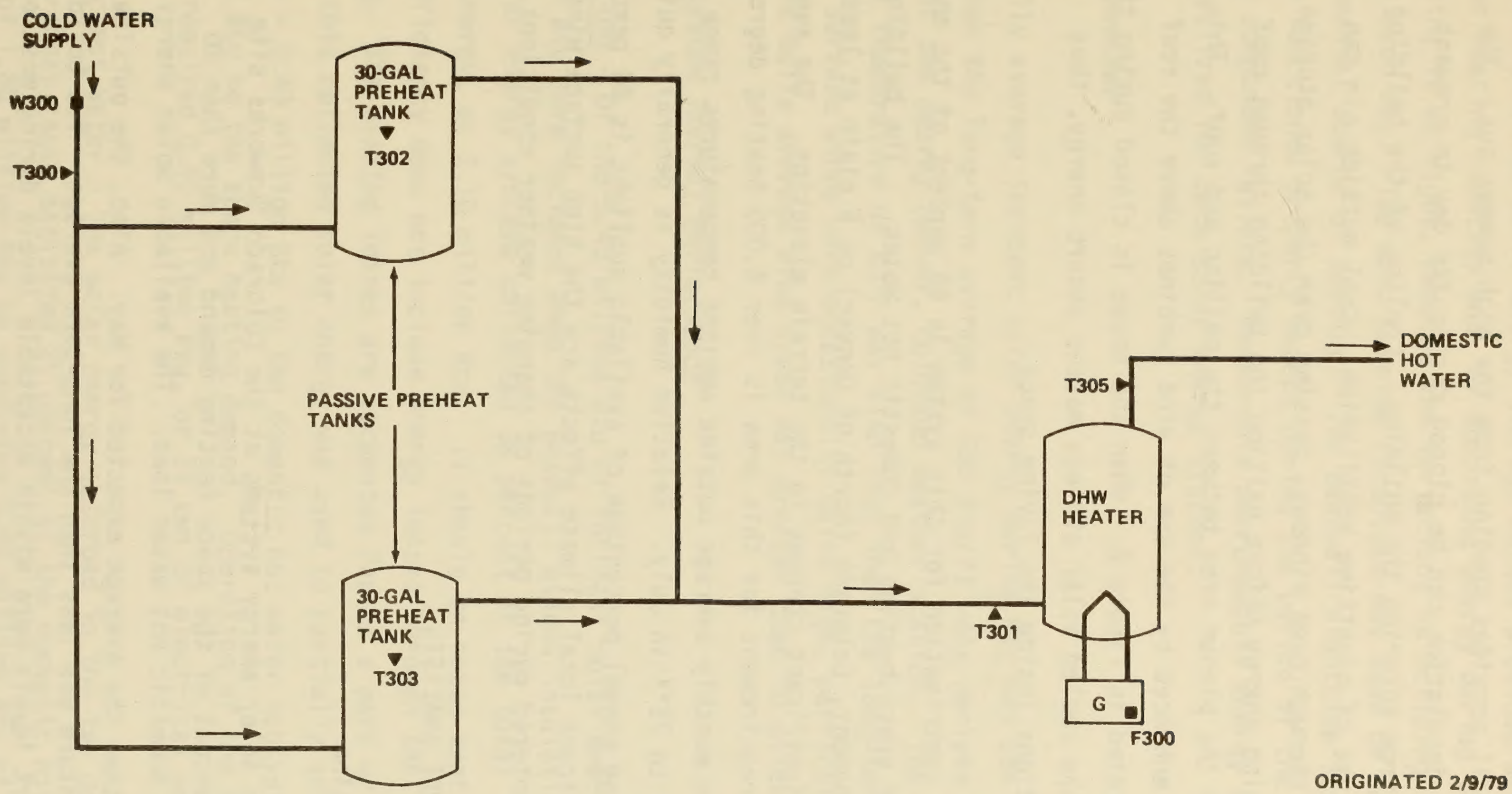

Figure 3. COLORADO SUNWORKS PASSIVE SOLAR DOMESTIC HOT WATER SYSTEM SCHEMATIC

Summer overheat protection is provided by several means. A roof overhang over the south wall provides shading from the high summer sun. The Beadwall movable insulation can be closed during the day to prevent solar radiation from entering the building. Cooling of the building is enhanced by the use of nighttime ventilation. Cool outside air can enter the house through open windows, passing over the solar storage masses and removing energy before exiting the building through roof vents located in the plenum area between the ceiling and roof. This natural flow is enhanced by the use of wind turbines above the roof vents as illustrated in Figure 2. When the house is closed during the daytime hours, the cooled solar storage masses absorb energy, thus tempering conditions inside the living space.

Predicted solar contribution for this system is 65 percent of the energy requirements for space heating and domestic hot water. The building is located near Longmont, Colorado (north of Denver) on a plain at least 10 miles east of significant changes in the terrain elevation. The average annual heating requirement for this area is over 6,000 heating degree-days. Long-term monthly average outside ambient temperatures range from 30°F in January to 73°F in July. Relative humidity is generally quite low. The average annual percentage of available sunlight is 64 percent. The most significant local climate effects are the high surface winds typically encountered during periods of changing weather conditions.

II. PERFORMANCE ANALYSIS

A. Introduction

During May, the solar energy systems at the Colorado Sunworks site satisfied 96 percent of the space heating demand and more than 20 percent of the domestic hot water load. The available solar energy was somewhat less than the average expected for May. Also, the outside ambient temperature was less than the long-term average. The building interior comfort levels were within acceptable levels during most of the month. The auxiliary heating system was used on two days due to a Beadwall system failure which occurred in conjunction with an injury to one of the occupants.

The heating system solar energy storage masses provided adequate reserve heating capacity and, by absorbing energy during the day and releasing it at night, reduced the variations in building temperature within each day. The wood burning fireplace was used on some days as a supplemental source of heating. The Beadwall nighttime insulation system functioned properly except during the period of the control system component failure. Measurable nonrenewable energy savings were realized for both solar energy systems.

B. Weather

The daily average incident solar energy during May was 584 Btu/ft^2-day, less than the long-term average of 890 Btu/ft^2-day derived from measurements at the nearby Denver, Colorado weather station. The average outside ambient temperature of 53°F was also less than the long-term average of 57°F. Surface winds were occasionally quite high, particularly on May 6, when the daily average wind speed was greater than 10 miles per hour.

C. System Thermal Performance

Collection - Of the 5.43 million Btu of incident solar energy, 3.92 million Btu were incident when the Beadwall window insulation was open. The solar energy systems collected 38 percent of the total incident solar energy, or 2.10 million Btu. It should be noted that this collection efficiency does not include energy losses through the south window glazing. The glazing losses are accounted for as a part of the load. All of this collected solar energy was used to partially satisfy the demands - 0.43 million Btu to the domestic hot water subsystem and 1.64 million Btu to the space heating demand. Operation of the Beadwall system required 0.10 million Btu, or 29 kwh of electrical energy.

Domestic Hot Water - The solar energy absorbed in the two domestic hot water preheat tanks satisifed 21 percent of the domestic hot water demand of 1.80 million Btu by supplying 0.43 million Btu of solar energy

from the preheat tanks. An average of 88 gallons of hot water were used each day by the four-member family living in the house. The solar contribution never reaches zero, even after the water in the preheat tanks has been completely replaced. This is due to energy transfer from the house (70°F) to the water in the preheat tanks (cold supply water temperature averages 50°F) since the preheat tanks are not completely thermally isolated from the interior of the building. Approximately 3.11 million Btu of natural gas was used as auxiliary fuel by the hot water heater. Assuming a conversion efficiency of 60 percent, then 1.87 million Btu of auxiliary thermal energy was delivered to the hot water. Using the assumed efficiency of 60 percent, the fossil fuel savings due to the hot water solar energy system are estimated to be 0.72 million Btu (722 cubic feet*) of natural gas. Daily variations in hot water solar fraction and hot water energy savings are due to variations in incident solar energy and daily variations in the hot water use, both in time of use and amount of use.

Space Heating - Since only a small amount of non-renewable energy was used for space heating during May, the solar energy system satisfied nearly 100 percent of the space heating demand. The reported space heating demand (reported as heating subsystem load) of 1.71 million Btu was reduced from the building load of 3.36 million Btu by 0.18 million Btu derived from fireplace operation and by 1.47 million Btu estimated from the use of the building (appliances, lights, people, etc.).

Comfort levels inside the building were reasonable during most of the month, ranging between 65°F and 75°F as daily averages. The 1°F difference in reported comfort levels between the north side of the building (zone 2) and the south side of the building (zone 1) indicates the capability of the system to transfer energy from the primary collection and storage area near the south wall to the remainder of the building. The only problem area was the north-west bedroom, which, as in past months, was generally several degrees cooler than the rest of the house due to the exposed, partially-bermed north wall.

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* Assumes 1,000 Btu per cubic foot.

The energy storage masses used for space heating provide good moderation of building interior temperatures. Temperature variations within a day averaged only 3°F for the month due to the capability of the storage masses to absorb excess energy during high incident energy periods and release the energy back to the conditioned space during low incident energy periods.

The thermal storage masses also provided a satisfactory energy reserve as illustrated by the system performance during the time period of May 6 through May 8. During this time period, the incident solar energy and the operational incident solar energy (incident energy when the Beadwall was open) were low. Since no auxiliary energy was used, the demand was satisfied entirely by energy released by the storage masses. The reported storage energy changes for those time periods do not exactly correlate with the demand (load) due to the lag in energy release from the different energy storage masses. Since all of the masses are not completely instrumented (the number of sensors required would be quite high), the rate of temperature decay of some of the mass is assumed to be similar to the instrumented portion of the mass. Since the energy level of all portions of the mass does not change simultaneously, then an error may be introduced corresponding to a time lag. On a daily basis this may produce a significant error when the building temperature is changing measurably. However, over a several day time period the errors are small.

D. Observations

The report parameter "ECSS Solar Conversion Efficiency" shown on the summary page of the attached computer printout is defined as the ratio of the solar energy used by the system to the total incident solar energy. As such, it represents an efficiency indication of the use of solar energy by the system. The value printed in this report, 38 percent, is computed with respect to the building use of solar energy. Since part of the solar energy used by the building is used to replace energy losses through the glazed areas, then this parameter would be expected to have a higher value than for an active solar energy system, or a higher value as compared to a building of more conventional structure.

An electrical component failure in the Beadwall control system caused the Beadwalls to fail in the closed condition early in the month. Within several days manual operation had been restored. Fully automatic operation is expected to resume early in June.

E. Energy Savings

Energy savings for the space heating system are presented against several rating scales. First, the building energy savings due to the use of passive solar heating, or the difference in the demand and the auxiliary used, are estimated to be 2.74 million Btu (2,740 cubic feet) of natural gas. If the savings are computed with respect to a building with equivalent energy conservation characteristics, but with a south wall similar in construction to the other building walls, the space heating comparison energy savings are approximately 2.01 million Btu (2,010 cubic feet) of natural gas. Finally, if the savings are computed with respect to the comparison building as operated to a set point temperature of 68°F to 70°F, the set point comparison energy savings becomes 1.91 million Btu (1,910 cubic feet) of natural gas. Operation of the fireplace, which provided 0.18 million Btu, is equivalent to the savings of 300 cubic feet of natural gas since an efficiency must be considered for conversion of fossil fuel energy to thermal energy (60 percent used). Additional energy savings for the solar energy systems are 722 cubic feet of gas due to the solar hot water preheat system. The power necessary to operate the Beadwall nighttime insulation system was 29 kwh. This energy is applied as a penalty to energy savings.

Total estimated energy consumption during May was 551 kwh of electrical energy, 3,234 cubic feet of natural gas, less than one percent of a cord of wood, and 2.08 million Btu of solar energy.

III. ACTION STATUS

At the next site visit, the sensor used to sense fireplace operation is to be changed from a thermal switch to a surface temperature type.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: COLORADO SUNWORKS — LONGMONT, COLORADO — SOLAR/1051-79/05
REPORT PERIOD: MAY,1979

SITE/SYSTEM DESCRIPTION:
THE COLORADO SUNWORKS SOLAR ENERGY SYSTEM PROVIDES SPACE HEATING AND DOMESTIC HOT WATER PREHEATING. THE PASSIVE HEATING SYSTEM CONSISTS OF A DRUMWALL COLLECTOR/STORAGE UNIT USED IN CONJUNCTION WITH A BEADWALL, TWO 30 GALLON TANKS POSITIONED NEXT TO THE SOUTH WALL AND INSULATED FROM THE INTERIOR LIVING SPACE. ENERGY CONSERVING FEATURES INCLUDE INCREASED INSULATION, THE USE OF BERMS ON THE NORTH, EAST AND WEST SIDES, AN AIRLOCK AND THE PLACEMENT OF THE GARAGE TO THE NORTHWEST TO SERVE AS A WINDBREAK.

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	5.430 MILLION BTU
	18118 BTU/SQ.FT.
COLLECTED SOLAR ENERGY	2.090 MILLION BTU
	6972 BTU/SQ.FT.
AVERAGE AMBIENT TEMPERATURE	53 DEGREES F
AVERAGE BUILDING TEMPERATURE	70 DEGREES F
ECSS SOLAR CONVERSION EFFICIENCY	0.38
ECSS OPERATING ENERGY	0.098 MILLION BTU
TOTAL SYSTEM OPERATING ENERGY	0.100 MILLION BTU
TOTAL ENERGY CONSUMED	5.410 MILLION BTU

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL
LOAD	1.797	1.707	N.A.	3.504 MILLION BTU
SOLAR FRACTION	21	96	N.A.	58 PERCENT
SOLAR ENERGY USED	0.433	1.642	N.A.	2.076 MILLION BTU
OPERATING ENERGY	N.A.	0.002	N.A.	0.100 MILLION BTU
AUX. THERMAL ENERGY	1.866	0.065	N.A.	1.930 MILLION BTU
AUX. ELECTRIC FUEL	N.A.	N.A.	N.A.	N.A. MILLION BTU
AUX. FOSSIL FUEL	3.109	0.124	N.A.	3.234 MILLION BTU
ELECTRICAL SAVINGS	N.A.	N.A.	N.A.	-0.100 MILLION BTU
FOSSIL SAVINGS	0.722	2.737	N.A.	3.459 MILLION BTU

SYSTEM PERFORMANCE FACTOR: 0.982

* DENOTES UNAVAILABLE DATA
@ DENOTES NULL DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM,FEBRUARY 28,1978, SOLAR/0004-78/18

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: COLORADO SUNWORKS   LONGMONT, COLORADO   SOLAR/1051-79/05
REPORT PERIOD: MAY,1979

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GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	5.729	GIGA JOULES
	205745	KJ/SQ.M.
COLLECTED SOLAR ENERGY	2.205	GIGA JOULES
	79179	KJ/SQ.M.
AVERAGE AMBIENT TEMPERATURE	12	DEGREES C
AVERAGE BUILDING TEMPERATURE	21	DEGREES C
ECSS SOLAR CONVERSION EFFICIENCY	0.38	
ECSS OPERATING ENERGY	0.103	GIGA JOULES
TOTAL SYSTEM OPERATING ENERGY	0.106	GIGA JOULES
TOTAL ENERGY CONSUMED	5.708	GIGA JOULES

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL	
LOAD	1.896	1.801	N.A.	3.697	GIGA JOULES
SOLAR FRACTION	21	96	N.A.	58	PERCENT
SOLAR ENERGY USED	0.457	1.733	N.A.	2.190	GIGA JOULES
OPERATING ENERGY	N.A.	0.002	N.A.	0.106	GIGA JOULES
AUX. THERMAL ENG	1.968	0.068	N.A.	2.036	GIGA JOULES
AUX. ELECTRIC FUEL	N.A.	N.A.	N.A.	N.A.	GIGA JOULES
AUX. FOSSIL FUEL	3.280	0.131	N.A.	3.412	GIGA JOULES
ELECTRICAL SAVINGS	N.A.	N.A.	N.A.	-0.106	GIGA JOULES
FOSSIL SAVINGS	0.762	2.888	N.A.	3.650	GIGA JOULES

SYSTEM PERFORMANCE FACTOR: 0.982

* DENOTES UNAVAILABLE DATA
@ DENOTES NULL DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM,FEBRUARY 28,1978, SOLAR/0004-78/18

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENERGY COLLECTION AND STORAGE SUBSYSTEM (ECSS)

SITE: COLORADO SUNWORKS LONGMONT, COLORADO SOLAR/1051-79/05
REPORT PERIOD: MAY,1979

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	AMBIENT TEMP DEG-F	ENERGY TO LOADS MILLION BTU	AUX THERMAL TO ECSS MILLION BTU	ECSS OPERATING ENERGY MILLION BTU	ECSS ENERGY REJECTED MILLION BTU	ECSS SOLAR CONVERSION EFFICIENCY
1	0.167	52	N	N	0.005	N	0.351
2	0.035	38	O	O	0.000	O	0.925
3	0.014	36	T	T	0.000	T	2.946
4	0.271	49			0.004		0.368
5	0.215	62	A	A	0.005	A	0.371
6	0.261	63	P	P	0.006	P	0.220
7	0.027	43	P	P	0.005	P	1.782
8	0.003	37	L	L	0.002	L	17.831
9	0.060	31	I	I	0.001	I	2.020
10	0.199	36	C	C	0.003	C	0.472
11	0.248	46	A	A	0.000	A	0.201
12	0.216	49	B	B	0.003	B	0.273
13	0.238	57	L	L	0.004	L	0.372
14	0.252	58	E	E	0.003	E	0.329
15	0.238	62			0.002		0.294
16	0.251	67			0.002		0.227
17	0.236	62			0.003		0.366
18	0.166	63			0.003		0.087
19	0.223	61			0.004		0.309
20	0.028	47			0.000		0.783
21	0.227	58			0.003		0.546
22	0.217	59			0.003		0.326
23	0.097	54			0.000		0.223
24	0.227	63			0.008		0.395
25	0.185	60			0.003		0.329
26	0.231	64			0.004		0.197
27	0.222	66			0.003		0.233
28	0.217	65			0.004		0.165
29	0.135	56			0.004		0.582
30	0.046	42			0.007		1.439
31	0.278	50			0.004		0.538
SUM	5.430	-	N.A.	N.A.	0.098	N.A.	-
AVG	0.175	53	N.A.	N.A.	0.003	N.A.	0.382
NBS ID	Q001	N113			Q102		N111

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SCLAR HEATING AND CCOLING CEMCNSTRATION PROGRAM

MONTHLY REPCRT
COLLECTOR ARRAY PERFORMANCE

SITE: COLORADO SUNWORKS   LONGMONT, CCLCRADO   SCLAR/1051-79/05
REPORT PERICD: MAY, 1979

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	OPERATIONAL INCIDENT ENERGY MILLION BTU	COLLECTED SOLAR ENERGY MILLICN BTU	DAYTIME AMBIENT TEMP DEG F	COLLECTOR ARRAY EFFICIENCY
1	0.167	C.124	N	62	N
2	0.035	0.000	C	35	C
3	0.014	C.000	T	37	T
4	0.271	0.131		60	
5	0.215	0.170	A	72	A
6	0.261	C.169	P	77	P
7	0.027	0.008	P	46	P
8	0.0C3	C.000	L	40	L
9	0.060	C.000	I	35	I
10	0.199	0.140	C	43	C
11	0.248	0.001	A	58	A
12	0.216	0.130	B	58	B
13	0.238	0.243	L	69	L
14	0.252	C.159	E	69	E
15	0.238	0.255		76	
16	0.251	0.273		80	
17	0.236	C.257		77	
18	0.166	0.185		71	
19	0.223	C.063		*	
20	0.028	0.006		44	
21	0.227	0.105		67	
22	0.217	C.185		71	
23	0.097	0.016		57	
24	0.227	0.191		*	
25	0.185	C.173		72	
26	0.231	0.197		75	
27	C.222	0.186		81	
28	0.217	0.182		*	
29	0.135	0.133		67	
30	0.046	0.028		41	
31	0.278	0.214		56	
SUM	5.430	3.921	2.C90	-	-
AVG	0.175	0.126	C.C67	61	0.385
NBSID	Q001		Q100		N100

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
HOT WATER SUBSYSTEM

SITE: COLORADO SUNWORKS   LONGMONT, COLORADO   SOLAR/1051-79/05
REPORT PERIOD: MAY,1979

DAY OF MON.	HOT WATER LOAD MILLION BTU	SOLAR FR.OF LOAD PER CENT	SOLAR ENERGY USED MILLION BTU	OPER ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSSIL FUEL MILLION BTU	ELECT ENERGY SAVINGS MILLION BTU	FOSSIL ENERGY SAVINGS MILLION BTU	SUP. WAT. TEMP DEG F	HOT WAT. TEMP DEG F	HOT WATER USED GAL
1	0.044	32	0.011	N	0.054	N	0.090	N	0.018	51	130	62
2	0.034	17	0.006	O	0.044	C	0.074	O	0.010	48	131	49
3	0.035	12	0.003	T	0.049	T	0.082	T	0.005	48	129	55
4	0.082	11	0.014		0.118		0.196		0.024	49	133	129
5	0.048	23	0.015	A	C.030	A	0.050	A	0.026	49	134	67
6	0.053	26	0.019	P	0.050	P	0.083	P	0.032	49	133	76
7	0.029	21	0.005	P	0.044	P	0.074	P	0.008	48	132	41
8	0.067	11	0.006	L	0.078	L	0.130	L	0.010	49	133	96
9	0.041	6	0.003	I	0.055	I	0.092	I	0.005	49	133	60
10	0.050	10	0.007	C	C.062	C	0.103	C	0.012	49	132	79
11	0.032	11	0.005	A	0.042	A	0.070	A	0.008	49	132	48
12	0.105	13	0.018	B	0.101	E	0.169	B	0.031	49	134	148
13	0.042	19	0.011	L	0.053	L	0.088	L	0.018	48	126	68
14	0.041	21	0.015	E	0.050	E	0.083	E	0.025	50	132	59
15	0.063	24	0.020		C.062		0.103		0.033	49	135	89
16	0.066	30	0.025		0.065		0.109		0.042	49	134	98
17	0.040	26	0.015		0.044		0.073		0.026	49	131	58
18	0.022	26	0.007		C.031		0.051		0.012	50	130	35
19	0.117	42	0.042		0.053		0.089		C.070	49	129	186
20	0.032	32	0.C08		0.043		0.072		0.013	50	131	51
21	0.060	18	0.014		C.069		0.115		0.023	50	134	86
22	0.052	20	0.013		0.049		0.081		0.022	51	134	76
23	0.103	21	0.021		0.093		0.155		0.034	50	126	157
24	0.092	22	0.024		0.085		0.142		0.040	51	122	164
25	0.027	18	0.005		0.052		0.087		0.008	51	129	44
26	0.064	19	0.015		C.054		0.090		0.025	51	134	110
27	0.054	31	0.023		0.048		0.080		0.038	52	130	83
28	0.081	29	0.023		0.066		0.109		0.038	51	125	128
29	0.048	24	0.015		0.051		0.084		0.024	53	128	74
30	0.039	19	0.006		0.047		0.078		0.010	52	134	61
31	0.137	14	0.020		0.123		0.206		0.033	53	135	205
SUM	1.797	-	0.433	N.A.	1.866	N.A.	3.109	N.A.	0.722	-	-	2741
AVG	0.058	21	0.014	N.A.	0.060	N.A.	0.100	N.A.	0.023	50	131	88
NBS	Q302	N300	Q300	Q303	Q3C1	Q3C5	Q306	Q311	Q313	N305	N307	N308

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SPACE HEATING SUBSYSTEM

SITE: COLORADO SUNWORKS LONGMONT, COLORADO SOLAR/1051-79/05
REPORT PERIOD: MAY,1979

DAY OF MON.	SPACE HEATING LOAD MILLION BTU	SOLAR FR.OF LOAD PCT	SOLAR ENERGY USED MILLION BTU	OPER ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSSIL FUEL MILLION BTU	ELECT ENERGY SAVINGS MILLION BTU	FOSSIL ENERGY SAVINGS MILLION BTU	BLDG TEMP DEG. F	AMB TEMP DEG. F
1	0.048	100	0.048	0.000	0.000	NOT APPLICABLE	0.000	NOT APPLICABLE	0.079	71	52
2	0.027	100	0.027	0.000	0.000		0.000		0.044	68	38
3	0.054	73	0.040	0.001	0.015		0.024		0.066	66	36
4	0.086	100	0.086	0.000	0.000		0.000		0.143	67	49
5	0.064	100	0.064	0.000	0.000		0.000		0.107	68	62
6	0.038	100	0.038	0.000	0.000		0.000		0.064	70	63
7	0.044	100	0.044	0.000	0.000		0.000		0.074	68	43
8	0.042	100	0.042	0.000	0.000		0.000		0.070	67	37
9	0.119	100	0.119	0.000	0.000		0.000		0.198	65	31
10	0.087	100	0.087	0.000	0.000		0.000		0.145	65	36
11	0.095	47	0.045	0.002	0.050		0.083		0.075	65	46
12	0.040	100	0.040	0.000	0.000		0.011		0.067	66	49
13	0.078	100	0.078	0.000	0.000		0.000		0.130	67	57
14	0.068	100	0.068	0.000	0.000		0.000		0.113	69	58
15	0.050	100	0.050	0.000	0.000		0.000		0.083	71	62
16	0.031	100	0.031	0.000	0.000		0.000		0.052	72	67
17	0.071	100	0.071	0.000	0.000		0.000		0.118	73	62
18	0.007	100	0.007	0.000	0.000		0.000		0.012	73	63
19	0.027	100	0.027	0.000	0.000		0.000		0.045	72	61
20	0.014	100	0.014	0.000	0.000		0.000		0.024	70	47
21	0.110	100	0.110	0.000	0.000		0.000		0.184	70	58
22	0.058	100	0.058	0.000	0.000		0.000		0.096	71	59
23	0.001	100	0.001	0.000	0.000		0.000		0.002	71	54
24	0.066	100	0.066	0.000	0.000		0.006		0.110	72	63
25	0.056	100	0.056	0.000	0.000		0.000		0.094	72	60
26	0.030	100	0.030	0.000	0.000		0.000		0.051	73	64
27	0.029	100	0.029	0.000	0.000		0.000		0.048	73	66
28	0.013	100	0.013	0.000	0.000		0.000		0.021	74	65
29	0.064	100	0.064	0.000	0.000		0.000		0.107	74	56
30	0.060	100	0.060	0.000	0.000		0.000		0.100	71	42
31	0.129	100	0.129	0.000	0.000		0.000		0.216	72	50
SUM	1.707	-	1.642	0.002	0.065	N.A.	0.124	N.A.	2.737	-	-
AVG	0.055	96	0.053	0.000	0.002	N.A.	0.004	N.A.	0.088	70	53
NBS	Q402	N400	Q400	Q403	Q401		Q410	Q415	Q417	N406	N113

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENVIRONMENTAL SUMMARY

SITE: COLORADO SUNWORKS LONGMONT, COLORADO SOLAR/1051-79/05
REPORT PERIOD: MAY,1979

DAY OF MONTH	TOTAL INSOLATION BTU/SQ.FT	DIFFUSE INSOLATION BTU/SQ.FT	AMBIENT TEMPERATURE DEG F	DAYTIME AMBIENT TEMP DEG F	RELATIVE HUMIDITY PERCENT	WIND DIRECTION DEGREES	WIND SPEED M.P.H.
1	557	N	52	62	60	18	5
2	118	O	38	35	100	39	7
3	48	T	36	37	93	147	7
4	904		49	60	66	193	3
5	718	A	62	72	44	230	5
6	870	P	63	77	31	254	10
7	91	P	43	46	72	*	9
8	9	L	37	40	100	53	9
9	202	I	31	35	98	48	9
10	665	C	36	43	82	0	2
11	828	A	46	58	61	33	6
12	719	B	49	58	60	*	4
13	795	L	57	69	45	321	6
14	841	E	58	69	55	58	4
15	795		62	76	56	28	5
16	836		67	80	43	338	7
17	787		62	77	58	102	4
18	554		63	71	65	61	4
19	743		61	*	71	75	5
20	93		47	44	97	96	9
21	757		58	67	65	*	3
22	724		59	71	72	73	5
23	325		54	57	81	79	3
24	756		63	*	69	26	4
25	617		60	72	76	27	8
26	771		64	75	55	0	1
27	739		66	81	53	*	4
28	725		65	*	56	*	3
29	452		56	67	79	66	7
30	153		42	41	93	*	5
31	927		50	56	74	137	3
SUM	18118	N.A.	-	-	-	-	-
AVG	584	N.A.	53	61	69	49	5
NBS ID	Q001		N113			N115	N114

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
PASSIVE SPACE HEATING

SITE: COLORADO SUNWORKS LONGMONT, COLORADO SOLAR/1051-79/05
REPORT PERIOD: MAY,1979

DAY OF MON	SPACE HEATING LOAD MILLION BTU	SOLAR ENERGY USED MILLION BTU	CHANGE IN STORE ENERGY MILLION BTU	AVERAGE STORAGE TEMP DEG F	DIRECT SOLAR UTIL EFFIC	AUX THERMAL USED MILLION BTU	BLDG TEMP DEG F	AMB TEMP DEG F	WIND AVG SPEED MPH	WIND AVG DIR DEG	SOLAR FR LOAD PER CENT
1	0.047	0.047	-0.019	72.6	0.351	0.000	71	52	4.7	18	100
2	0.026	0.026	-0.066	70.8	0.925	0.000	68	38	6.7	39	100
3	0.054	0.039	-0.059	68.3	2.946	0.014	66	36	6.6	147	73
4	0.085	0.085	0.030	67.7	0.368	0.000	67	49	3.3	193	100
5	0.064	0.064	0.028	68.7	0.371	0.000	68	62	5.4	230	100
6	0.038	0.038	0.037	70.1	0.220	0.000	70	63	9.9	254	100
7	0.044	0.044	-0.053	69.8	1.782	0.000	68	43	9.1	*	100
8	0.041	0.041	-0.046	68.0	17.831	0.000	67	37	8.6	53	100
9	0.119	0.119	-0.033	66.3	2.020	0.000	65	31	8.9	48	100
10	0.086	0.086	0.009	65.9	0.472	0.000	65	36	2.0	0	100
11	0.094	0.044	-0.026	65.2	0.201	0.049	65	46	6.1	33	47
12	0.040	0.040	0.032	65.6	0.273	0.000	66	49	3.5	*	100
13	0.077	0.077	0.045	66.9	0.372	0.000	67	57	6.2	321	100
14	0.067	0.067	0.041	68.6	0.329	0.000	69	58	4.3	58	100
15	0.050	0.050	0.043	70.4	0.294	0.000	71	62	4.6	28	100
16	0.031	0.031	0.037	72.2	0.227	0.000	72	67	6.7	338	100
17	0.071	0.071	0.031	73.4	0.365	0.000	73	62	4.2	102	100
18	0.007	0.007	0.004	74.1	0.087	0.000	73	63	4.0	61	100
19	0.026	0.026	-0.036	73.2	0.309	0.000	72	61	4.9	75	100
20	0.014	0.014	-0.056	71.7	0.783	0.000	70	47	9.1	96	100
21	0.110	0.110	0.010	70.5	0.546	0.000	70	58	3.4	*	100
22	0.057	0.057	0.027	71.4	0.326	0.000	71	59	5.2	73	100
23	0.001	0.001	-0.037	71.3	0.223	0.000	71	54	3.0	79	100
24	0.065	0.065	0.047	71.7	0.395	0.000	72	63	3.8	26	100
25	0.056	0.056	0.011	72.8	0.329	0.000	72	60	8.1	27	100
26	0.030	0.030	0.026	73.4	0.197	0.000	73	64	1.4	0	100
27	0.028	0.028	0.016	74.1	0.233	0.000	73	66	3.9	*	100
28	0.012	0.012	0.020	75.1	0.165	0.000	74	65	3.4	*	100
29	0.064	0.064	-0.013	75.2	0.582	0.000	74	56	6.8	66	100
30	0.059	0.059	-0.059	73.8	1.439	0.000	71	42	4.7	*	100
31	0.129	0.129	0.009	72.9	0.538	0.000	72	50	3.1	137	100
SUM	1.706	1.642	0.004	-	-	0.064	-	-	-	-	-
AVG	0.055	0.052	0.000	70.7	0.382	0.002	70	53	5.3	49	96
NBS	Q402	Q400	Q202			Q401	N405	N113	N114	N115	N400

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
PASSIVE SYSTEM ENVIRONMENT

SITE: COLORADO SUNWORKS LONGMONT, COLORADO SOLAR/1051-79/05
REPORT PERIOD: MAY,1979

DAY OF MON	BUILDING COMFORT ZONE 1	BLDG COMF ZONE 2	BUILDING TEMP MIDNIGHT DEG F	BUILDING TEMP 6 AM DEG F	BUILDING TEMP NOON DEG F	BUILDING TEMP 6 PM DEG F	INTERIOR RELATIVE HUMIDITY PERCENT	AMB TEMP DEG F	DAYTIME AMB TEMP DEG F	INCIDENT SOLAR ENERGY MILLION BTU	AVG STOR TEMP DEG F
1	71	70	70	69	73	71	38	52	62	0.167	73
2	69	68	67	69	68	68	40	38	35	0.035	71
3	66	66	66	66	65	66	38	36	37	0.014	68
4	67	67	67	65	68	69	41	49	60	0.271	68
5	68	67	69	66	69	70	44	62	72	0.215	69
6	70	68	69	67	70	71	37	63	77	0.261	70
7	69	68	67	68	68	68	38	43	46	0.027	70
8	67	67	66	67	67	67	44	37	40	0.003	68
9	65	65	65	65	65	65	45	31	35	0.060	66
10	65	65	64	64	66	66	45	36	43	0.199	66
11	65	65	66	64	64	66	48	46	58	0.248	65
12	66	66	66	64	67	68	50	49	58	0.216	66
13	67	67	68	65	68	69	54	57	69	0.238	67
14	69	69	70	67	70	71	56	58	69	0.252	69
15	71	70	71	68	72	73	58	62	76	0.238	70
16	72	71	72	70	73	74	59	67	80	0.251	72
17	73	72	73	71	74	75	60	62	77	0.236	73
18	74	72	72	72	73	74	57	63	71	0.166	74
19	73	71	72	71	71	73	50	61	*	0.223	73
20	71	70	69	71	70	69	50	47	44	0.028	72
21	70	70	71	68	69	72	50	58	67	0.227	71
22	71	71	71	69	72	73	51	59	71	0.217	71
23	71	71	70	70	71	71	51	54	57	0.097	71
24	72	71	72	69	73	74	53	63	*	0.227	72
25	72	71	72	70	73	73	51	60	72	0.185	73
26	73	72	72	71	73	75	50	64	75	0.231	73
27	74	72	74	70	74	76	44	66	81	0.222	74
28	75	73	80	79	82	83	45	65	*	0.217	75
29	74	73	73	72	75	74	45	56	67	0.135	75
30	72	71	70	72	71	71	45	42	41	0.046	74
31	72	72	71	69	72	73	46	50	56	0.278	73
SUM	-	-	-	-	-	-	-	-	-	5.430	-
AVG	70	69	70	69	70	71	48	53	61	0.175	71
NBS								N113			

* DENOTES UNAVAILABLE DATA.
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*U.S. GOVERNMENT PRINTING OFFICE: 1979-640-189/4048. Region 4.